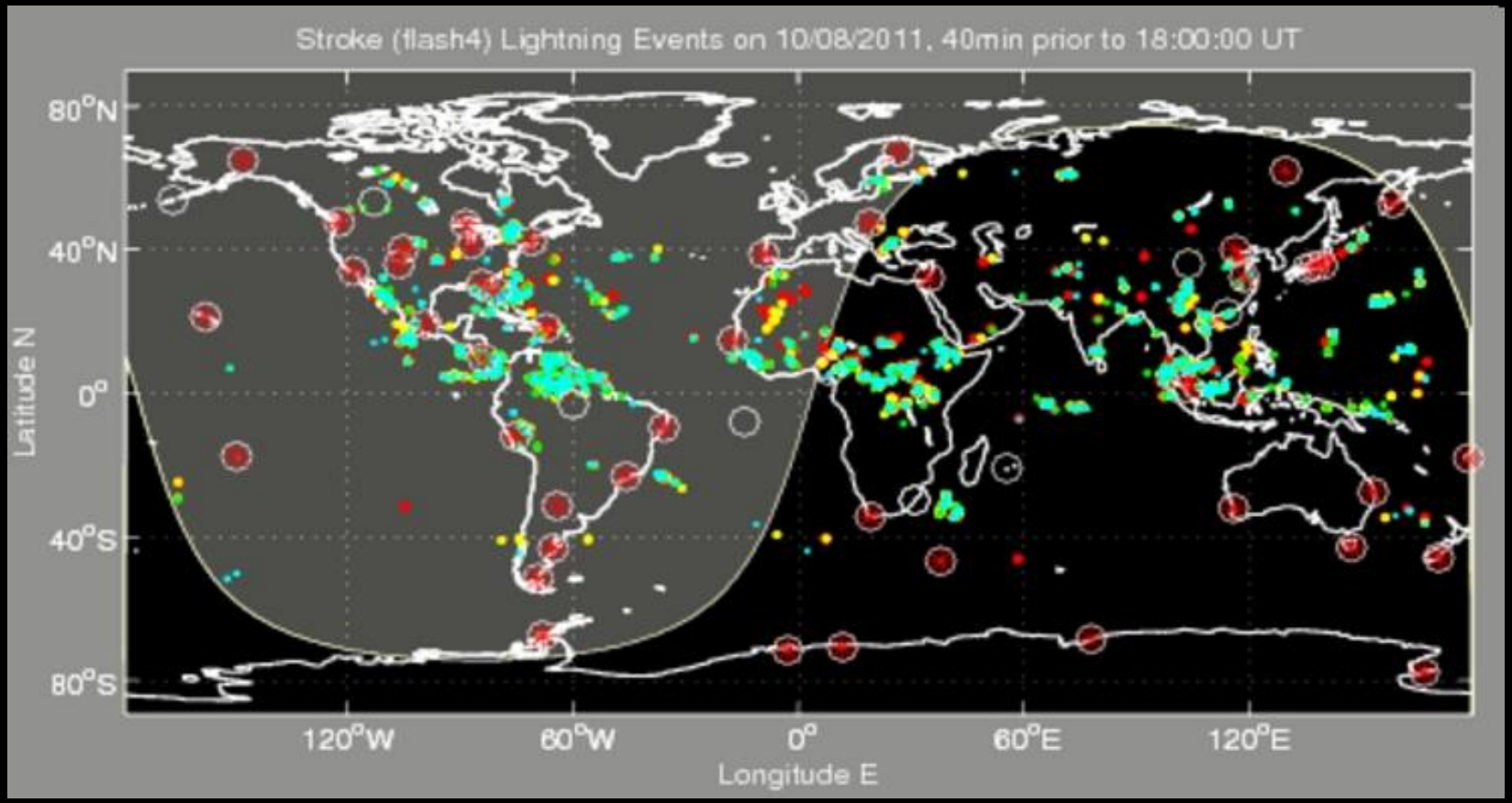
WWLLN

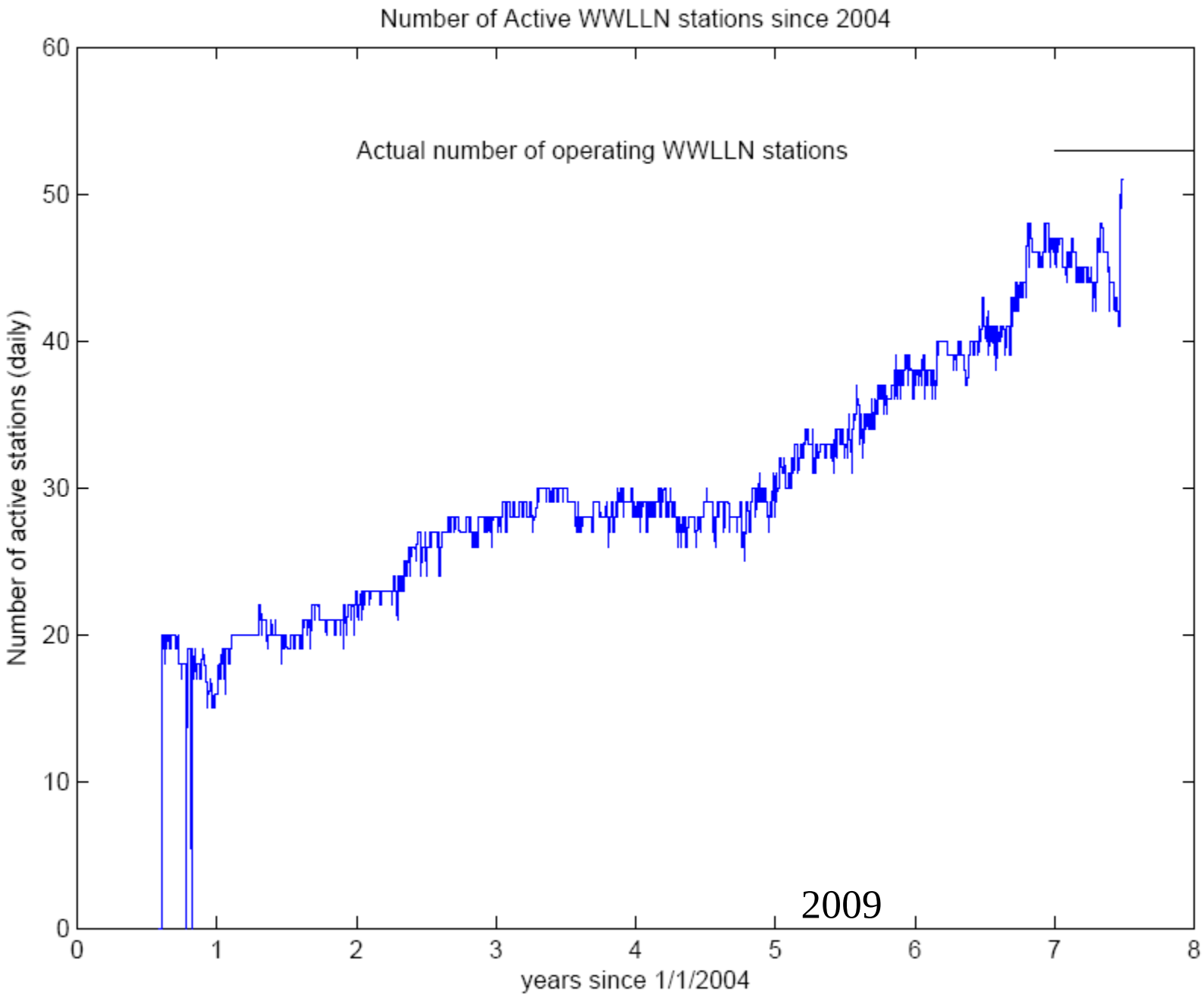
(World Wide Lightning Location Network)

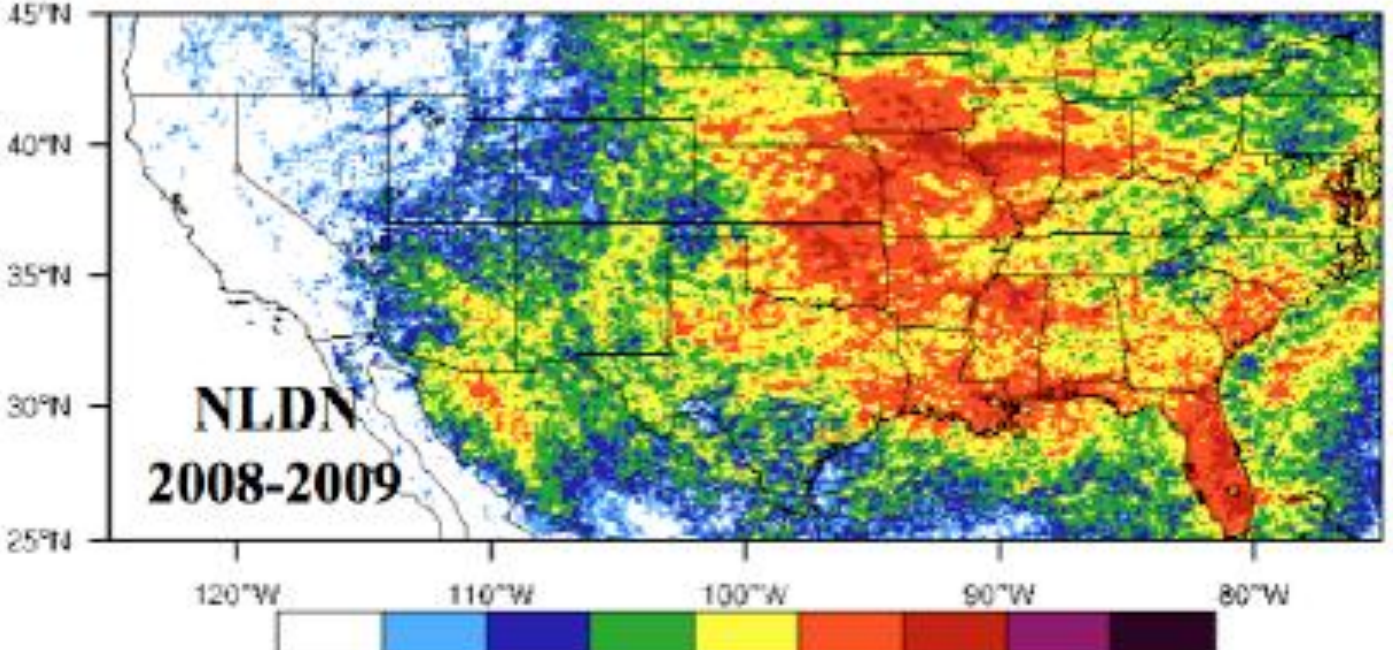


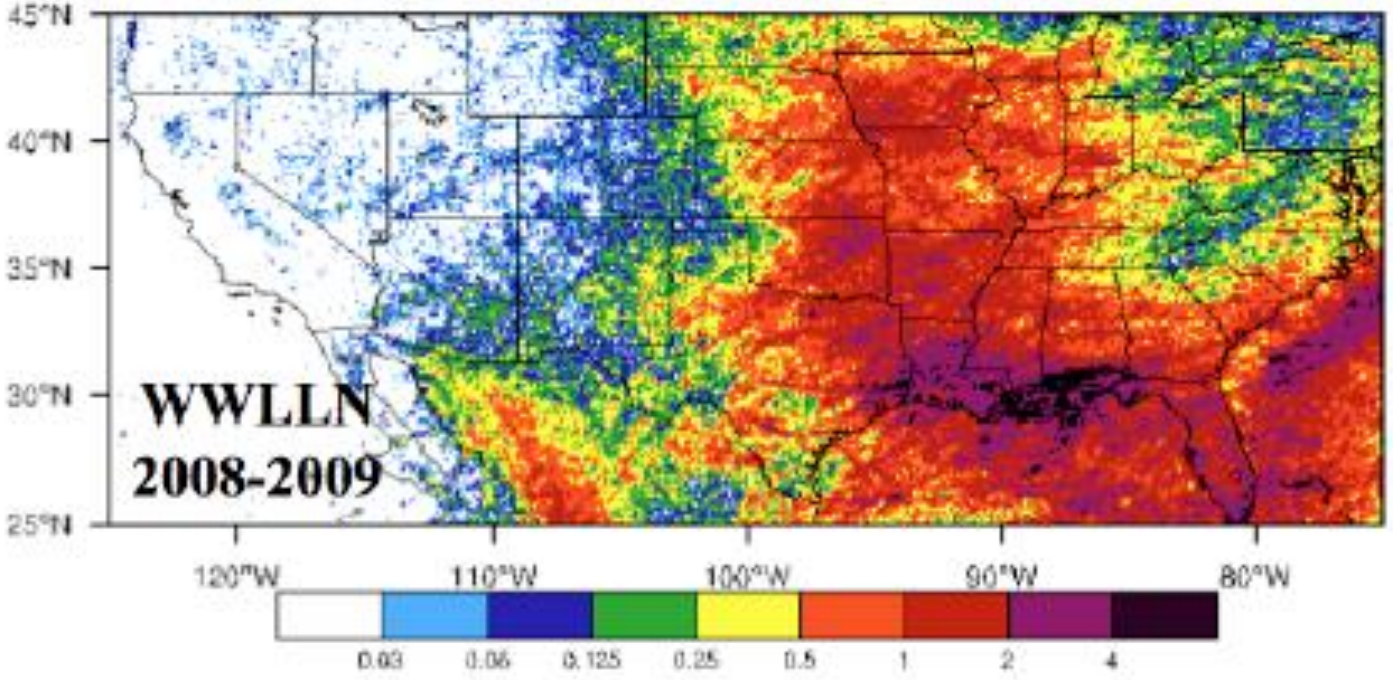
By Prof. Robert Holzworth, Director of WWLLN, University of Washington

WWLLN statistics

- 55 stations operating (60 actually delivered) 12-14 million strokes/month
- Detection Efficiency Estimates:
  - >95% of lightning producing thunderstorms
  - ~11 to 20% of global total strokes
  - >30% of strokes over 60 kA

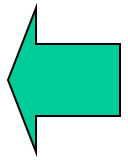

Number of Active WWLLN stations since 2004
Actual number of operating WWLLN stations
Number of active stations (daily)
years since 1/1/2004
0
10
20
30
40
50
60
0
1
2
3
4
5
6
7
8
2009


45°N
40°N
35°N
30°N
25°N
NLDN
2008-2009
120°W
110°W
100°W
90°W
80°W


45°N
40°N
35°N
30°N
25°N
WWLLN
2008-2009
120°W
110°W
100°W
90°W
80°W
0.03
0.06
0.125
0.25
0.5
1
2
4

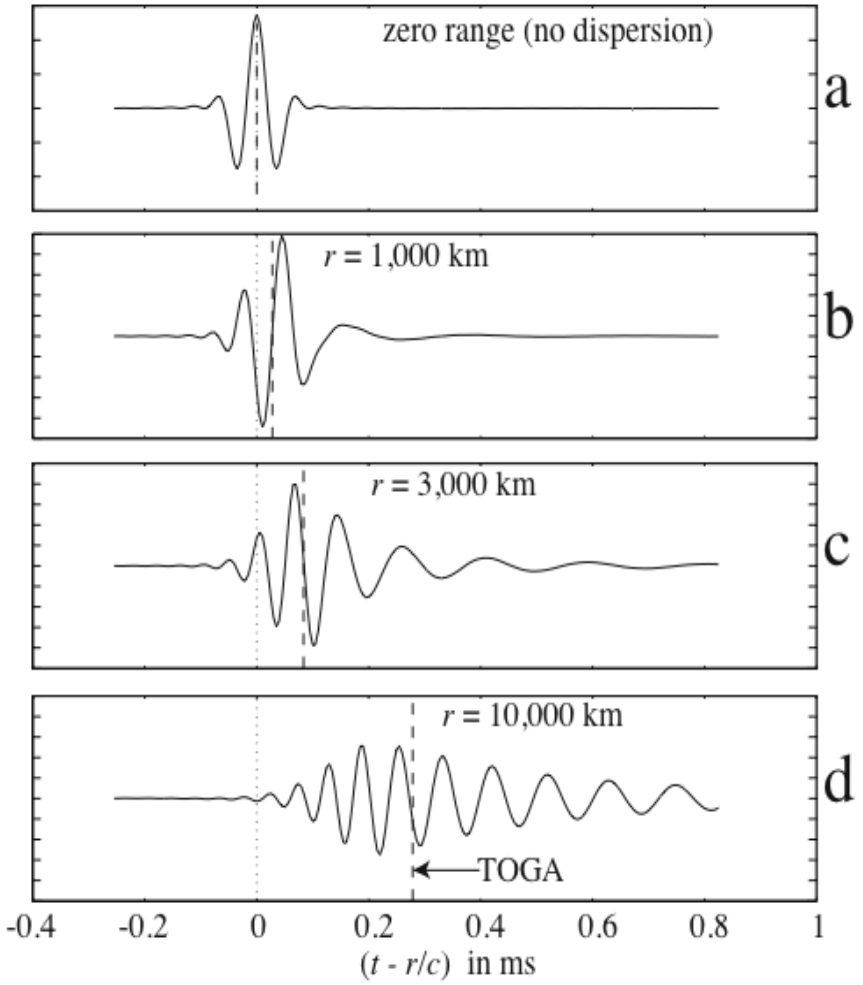
Detection Efficiency compared to NLDN

Year	2006-2007	2007-2008	2008-2009
All WWLLN flashes	2,732,366	3,228,444	6,154,394
All (CG) NLDN flashes	29,614,920	27,567,606	24,839,997
Coincidences	1,147,815	1,346,692	2,558,809
CG DE [%]	3.88	4.89	10.30
IC DE [%]	1.78	2.28	4.82
CG + IC DE [%]	2.31	2.93	6.19



* Study done by independent researcher at UCLA (2010)

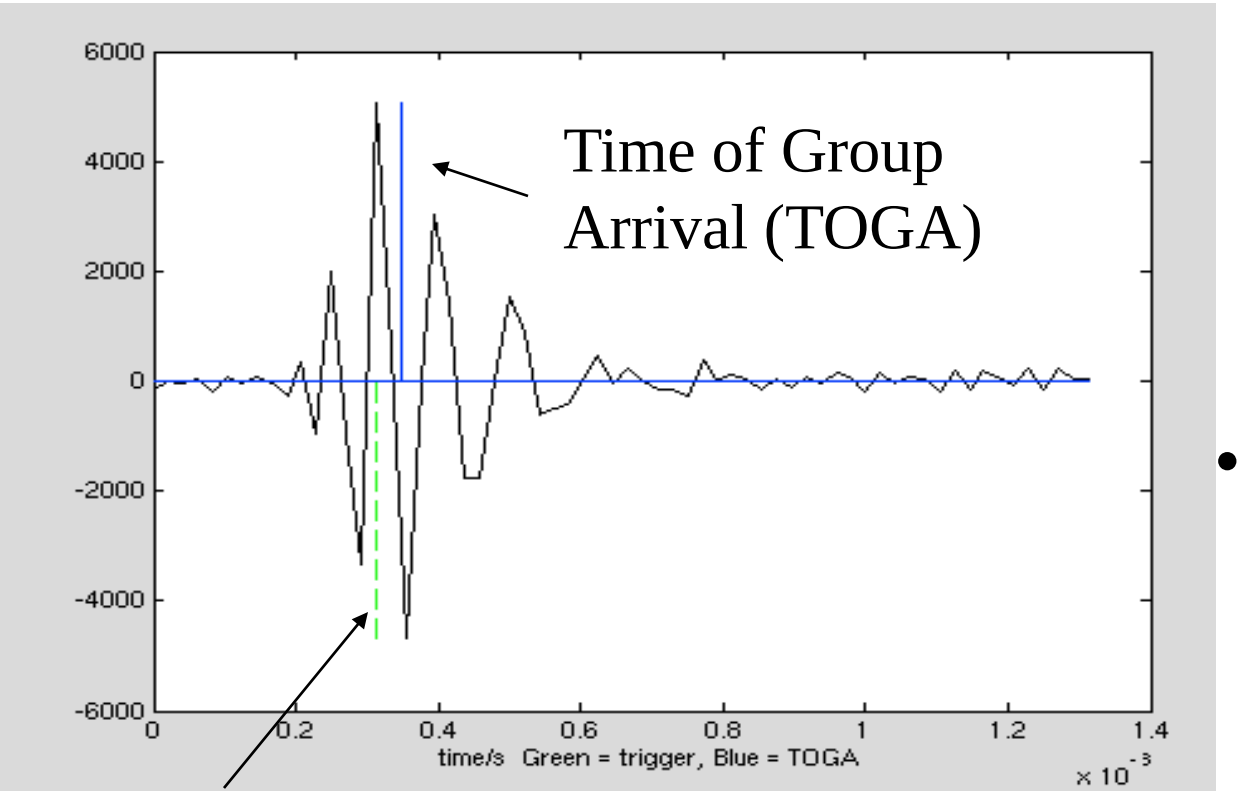
How does it work?
TOGA Fourier Synthesis: Dispersion Case



- **Problem Detecting Global Lightning: The Sferic from the lightning strike has many frequencies and these waves travel at frequency dependent speeds so all 100 waves we use in our analysis don't come into phase.**

TOGA Provides Better Location and Timing Accuracy than Trigger Time

Using TOGA instead of trigger time allows timing to <30 μs and location accuracy to 5-10 km anywhere in the world.



- Sferic detected with TOGA marked (blue) and Trigger Time marked green

Each WWLLN Station detects lightning out to 12,000 km at night and 8,000 km during the day

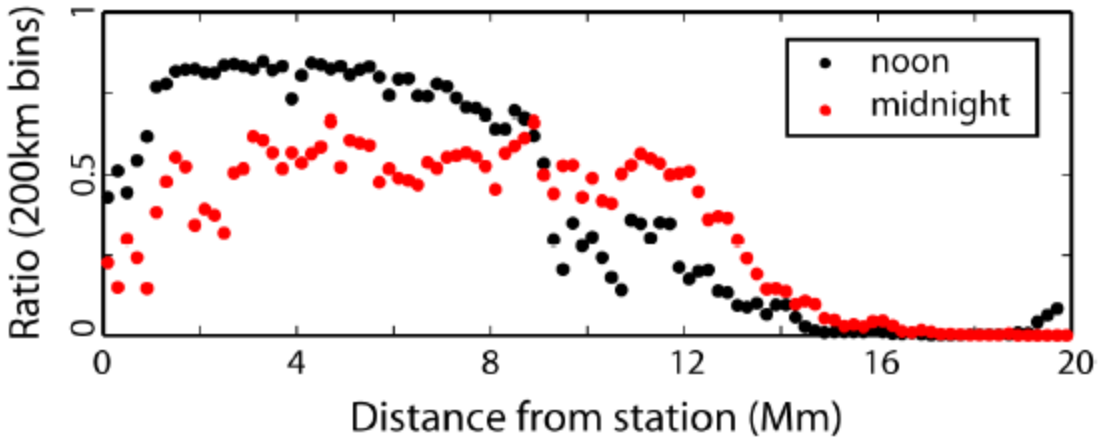


Fig. 7. Ratio of the number of events detected by the Darwin station to the number of events detected at the same range from Darwin by the network as a whole. The black dots show this ratio for ±2 h around local noon, while the red dots are for ±2 h around local midnight.

Energy/Stroke now being produced

- APP files now have power per stroke information. Being produced daily.
- Historical power data back to April 2009.
- Regular production planned by end of year

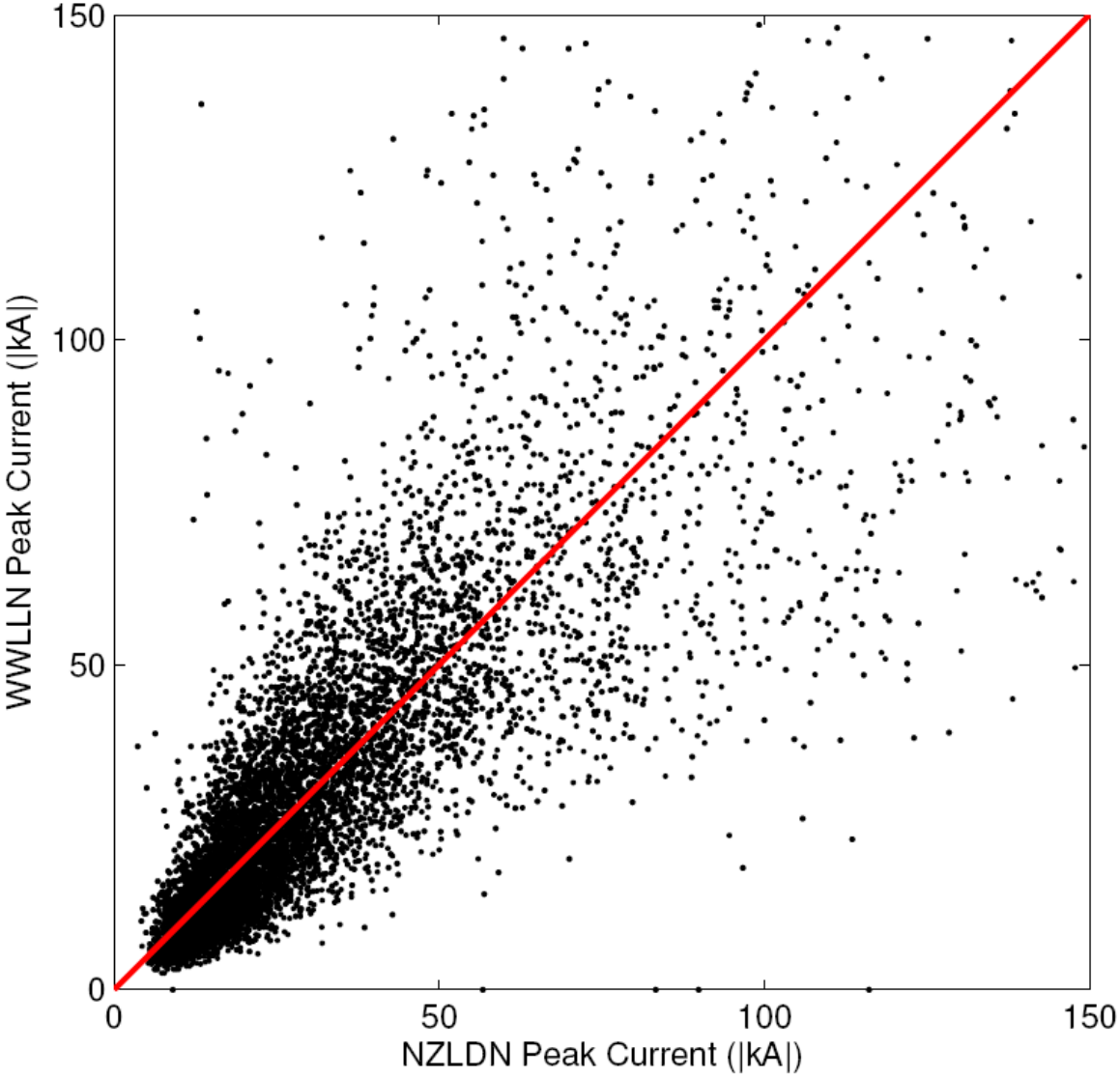
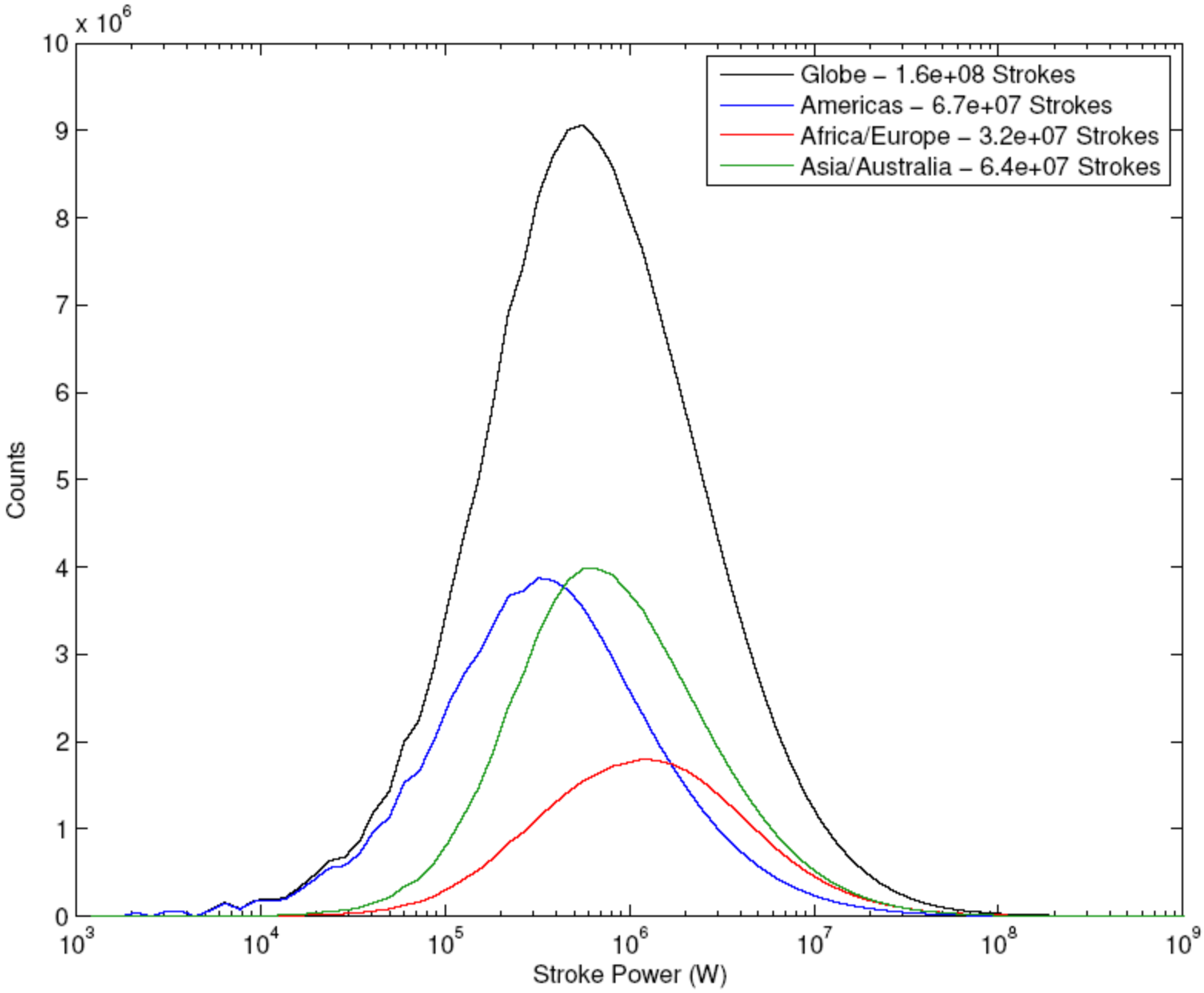


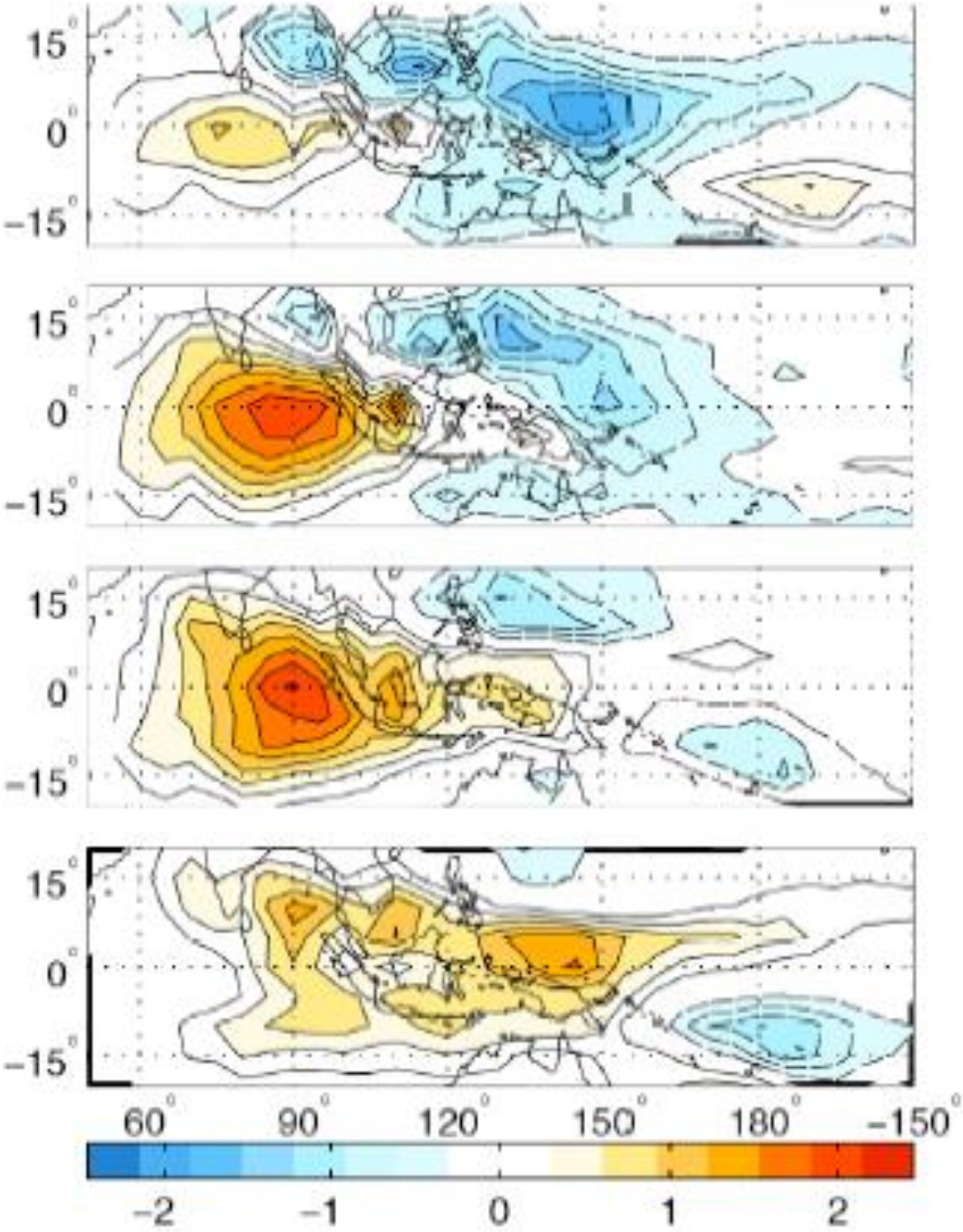
Figure 6. Hutchins et al, 2011
WWLLN peak current versus NZLDN peak current for three time periods in 2009 using 12,015 matches. 86% of strokes are within range of the unity line (red solid line) with uncertainty taken into account. 97.5% of NZLDN-WWLLN matched strokes shown (others out of range)


x 10^6
10
9
8
7
6
5
4
3
2
1
0
Counts
Globe – 1.6e+08 Strokes
Americas – 6.7e+07 Strokes
Africa/Europe – 3.2e+07 Strokes
Asia/Australia – 6.4e+07 Strokes
10^3
10^4
10^5
10^6
10^7
10^8
10^9
Stroke Power (W)

WWLLN stimulates New Research

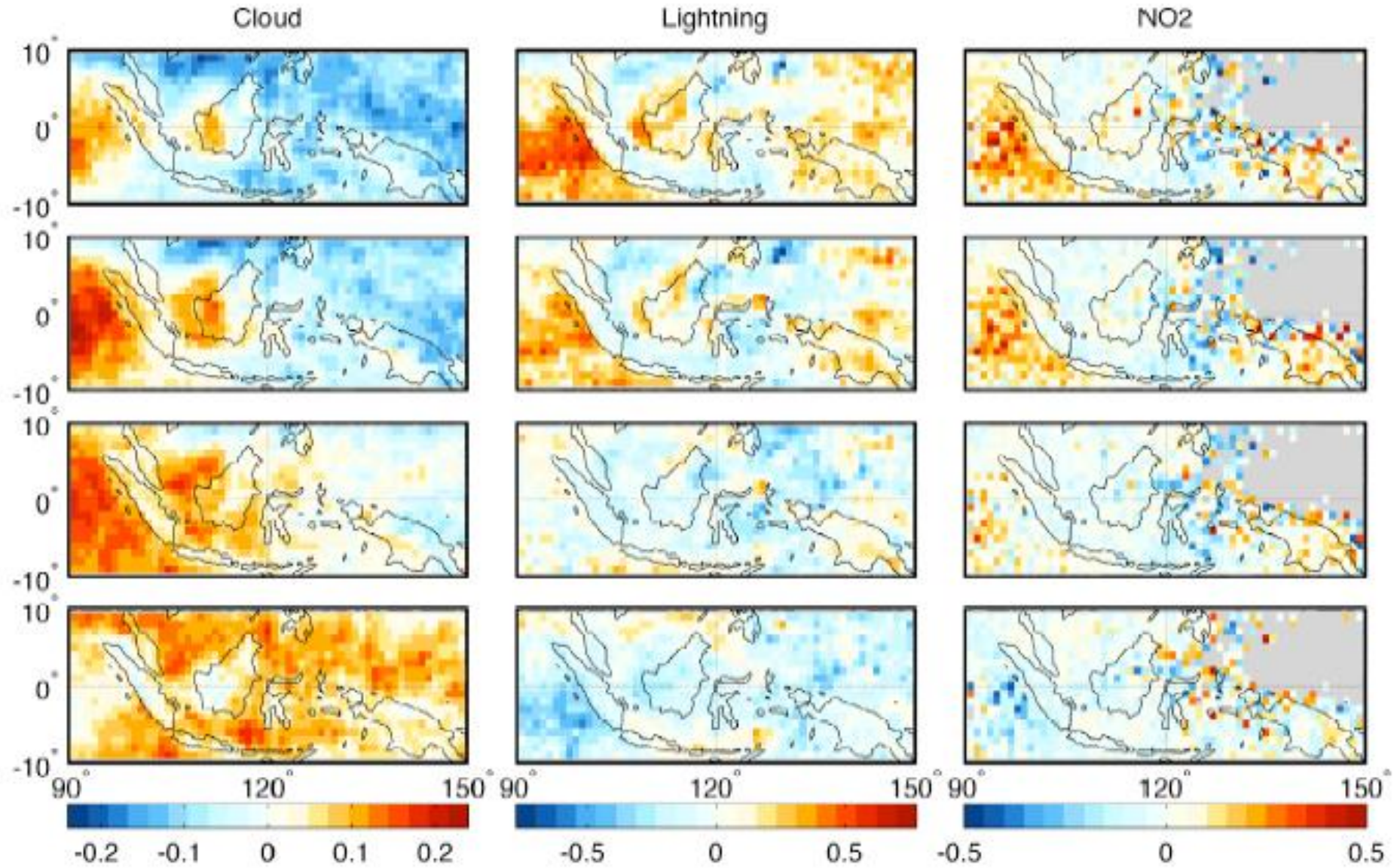
- Ionospheric Plasma effects
  - Sprites/Jets/Elve research
  - Ionospheric EMP
  - VLF propagation (tweeks determine D-region density)
- Atmospheric Science
  - Hurricanes dynamics
  - African Easterly waves
  - MJO shown to have strong lightning signal
- Terrestrial Gamma Flashes
- Volcano Ash Cloud Lightning

See http://wwlln.net/publications/



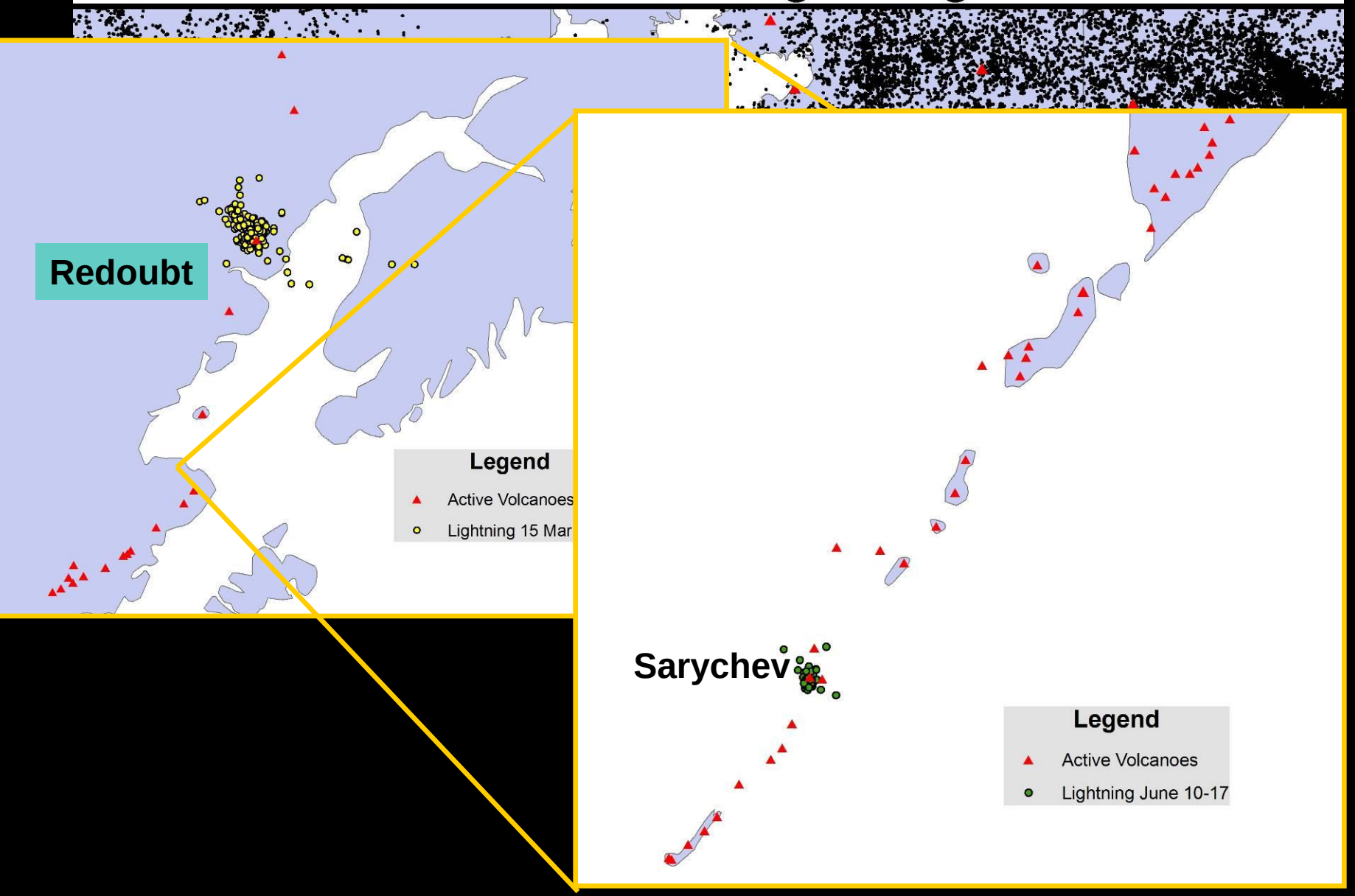
80-day high-pass filtered 5° latitude × 5° longitude **Global Precipitation Climatology Project precipitation** (mm day-1) regressed onto time series representing phases 1-4 (top to bottom) of MJO index. Adapted from *Virts and Wallace* [2010].

Virts, Katrina S., Joel A. Thornton, John M. Wallace, Michael L. Hutchins, Robert H. Holzworth, and Abram R. Jacobson, Daily, seasonal, and intraseasonal relationships between lightning and NO2 over the Maritime Continent, **Geophys. Res. Lett., doi:10.1029/2011GL048578 (in press), 2011**



80-day high-pass filtered cloud fraction (left), lightning (middle), and NO2 (right) regressed onto time series representing MJO phases 1 (top) to 4 (bottom). Regression coefficients are scaled by the annual mean; gray shading indicates areas of low annual mean

WWLLN-Detected Lightning: 2009



USGS

ESS

WWLLN Volcano Monitor

(see http://wwlln.net/volcanoMonitor.html)

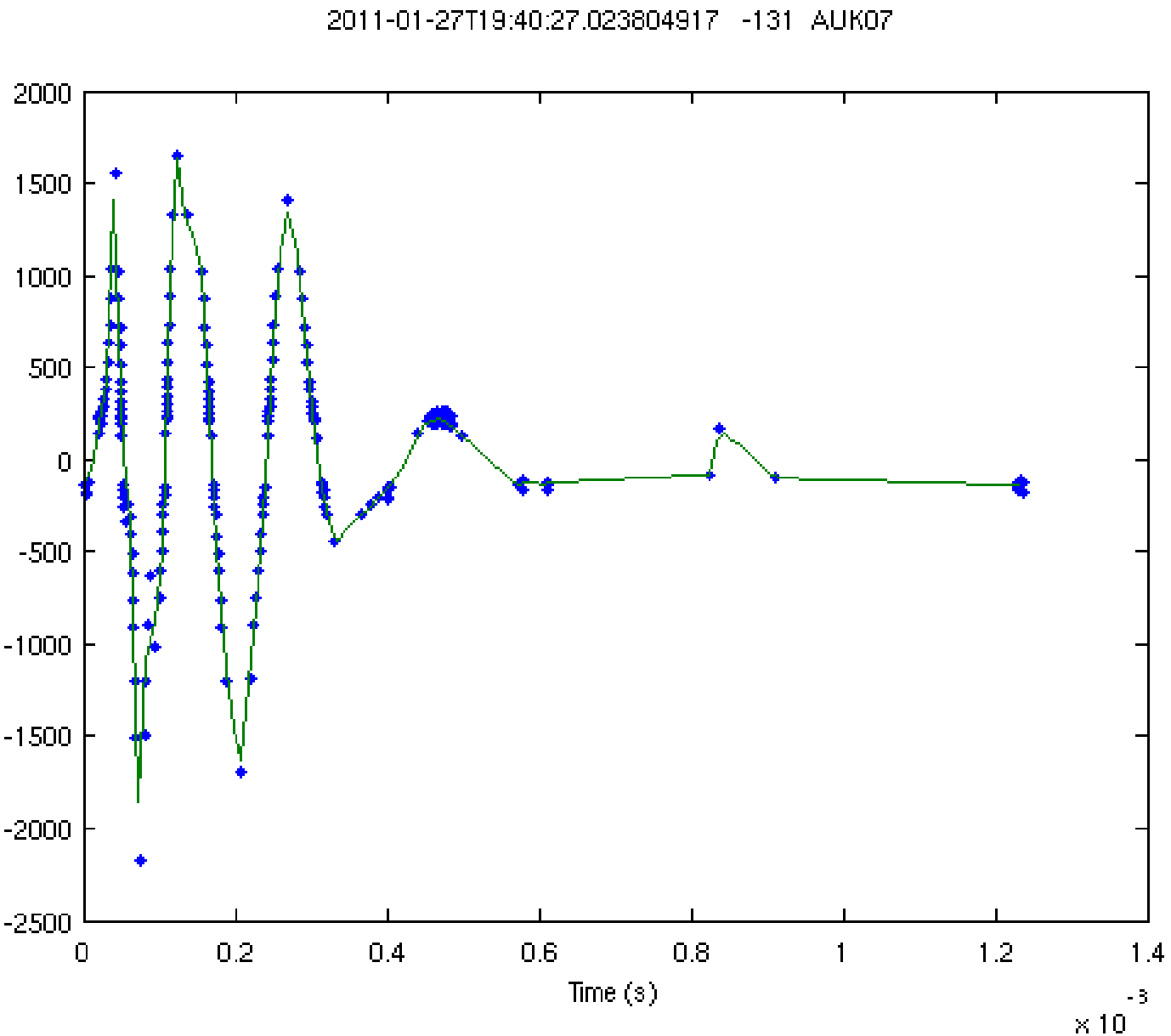
WWLLN examines 1,562 volcano caldera every minute to look for lightning within two rings: within 20 km of the caldera, and with a larger ring at 100 km. If new lightning is found in the inner ring, and over the last hour there is MORE lightning in the inner ring, than the outer ring, WWLLN sends an ALERT message to the USGS about the possibility that an eruption is underway. Presently alerts are only sent for Alaskan Volcano Observatory volcanos, but ALL volcanos are monitored every minute.

Since turning on the Alert system in Oct 2010, WWLLN has correctly identified three explosive eruptions, giving volcano centers up to 1 hour early warning, compared to available alternative methods of eruption detection and confirmation. Most recent Dec 31, 2010 (Kizimen, Kamchatka) (this is old now)
http://flash3.ess.washington.edu/USGS/AVO/archive/20101231/

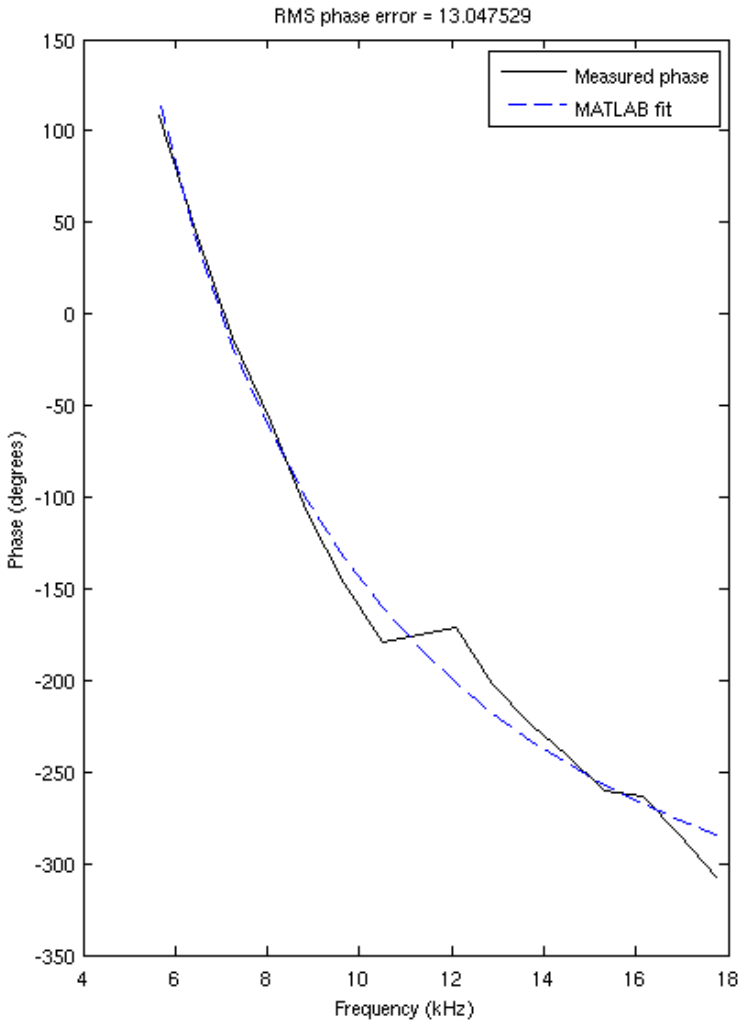
Future Plans

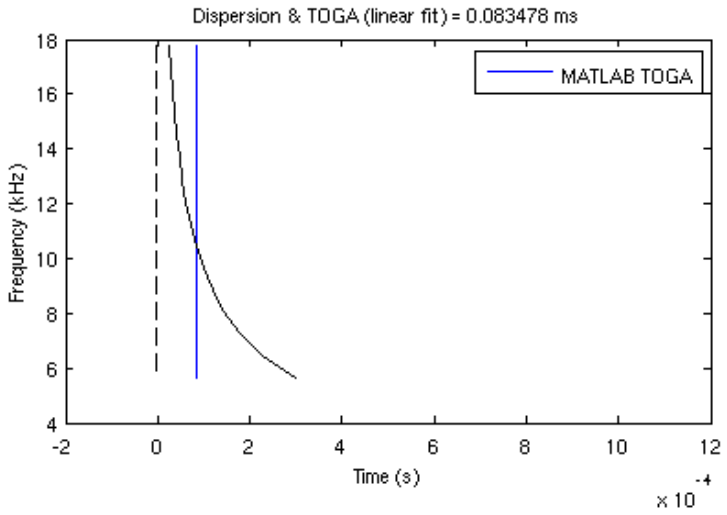
- Add Energy per stroke and dynamic detection efficiency to real time processing (for now it is being produced as a daily file, once a day, offline from the regular processing)
- Calculate a dynamic (realtime) Detection Efficiency
- Combine raw data from ENTLN with WWLLN to greatly improve the detection efficiency

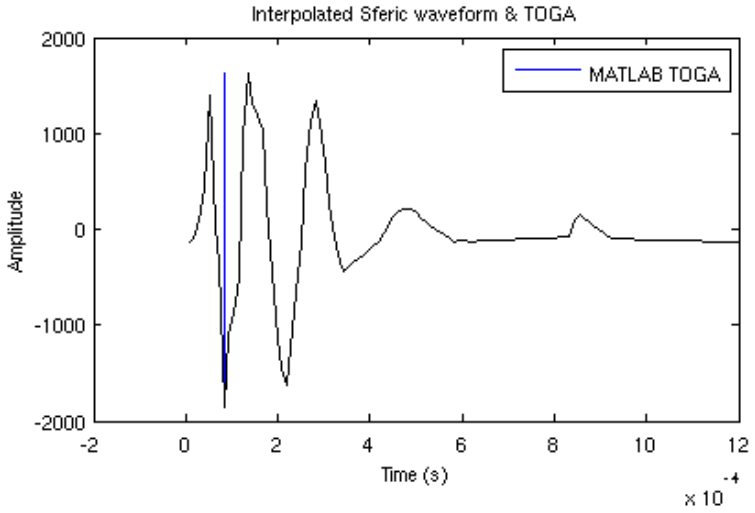
WTLN waveform



Finding TOGA from Weatherbug waveform

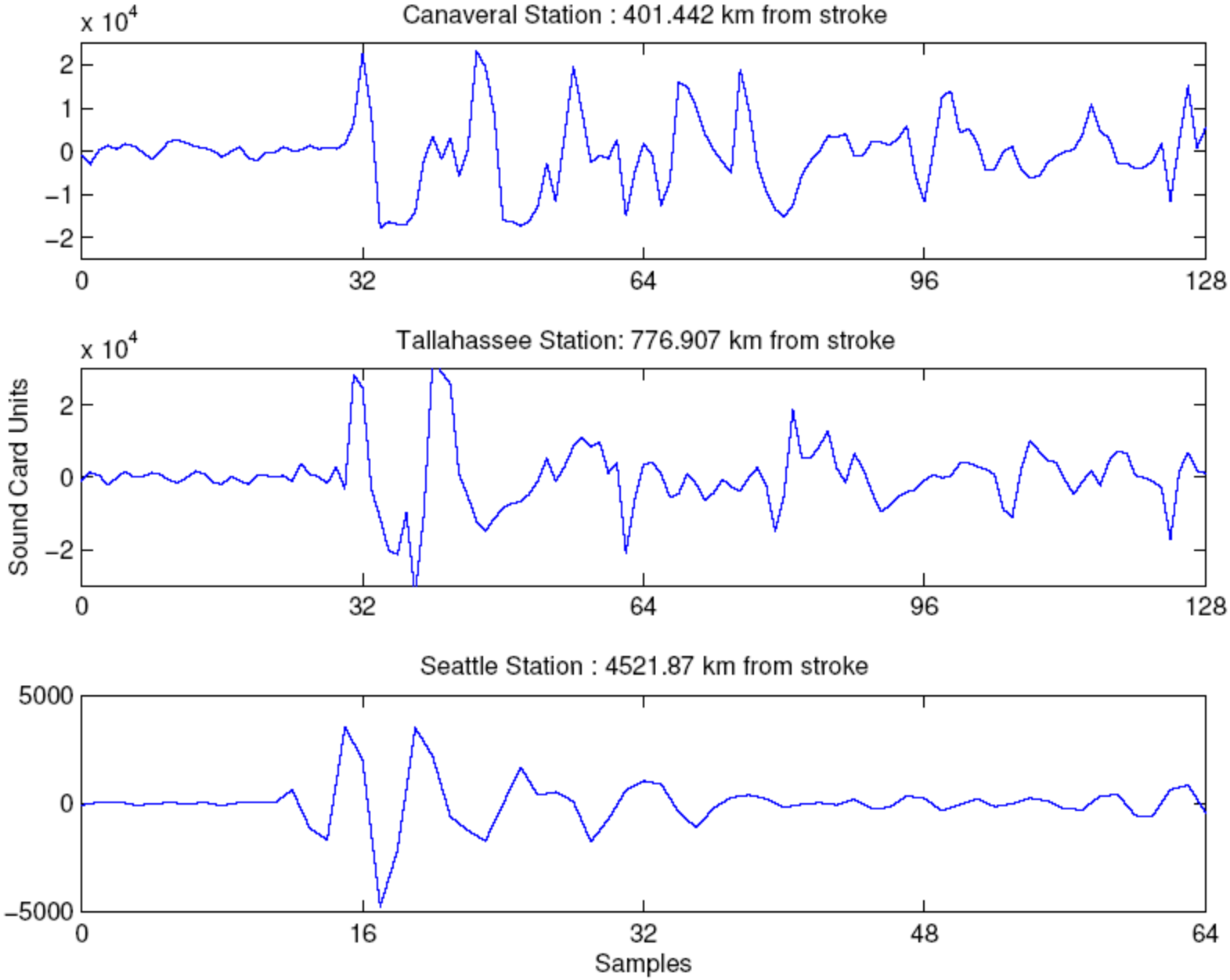






We are Research Driven

- WWLLN is a consortium of researchers.
- Our goal is to detect as much of the global lightning as possible with high time and space accuracy. We cannot afford data dropouts. We value redundancy and have removed possible single point failures.
- We collect the data and we use it in our own research. If it is useful to you, then we'll be glad to sell it to you, too.


Canaveral Station : 401.442 km from stroke
x 10^4
2
1
0
−1
−2
0
32
64
96
128
Tallahassee Station: 776.907 km from stroke
x 10^4
Sound Card Units
2
0
−2
0
32
64
96
128
Seattle Station : 4521.87 km from stroke
5000
0
−5000
0
16
32
48
64
Samples